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Szymber et al.

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[54] **RANDOM SELECTION POSITIONING CONTROL SYSTEM HAVING MULTIDIGIT CONTROL SIGNALS**

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[51] Int. Cl. H04q 3/00, H04q 5/00

[58] Field of Search 318/604, 664; 340/147, 149

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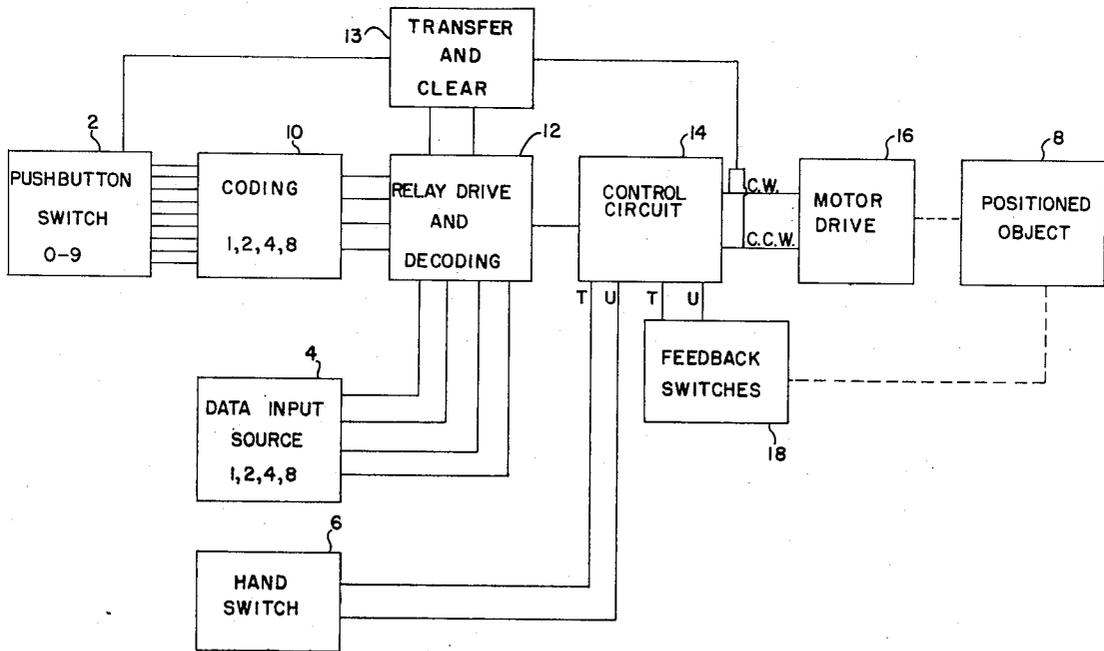
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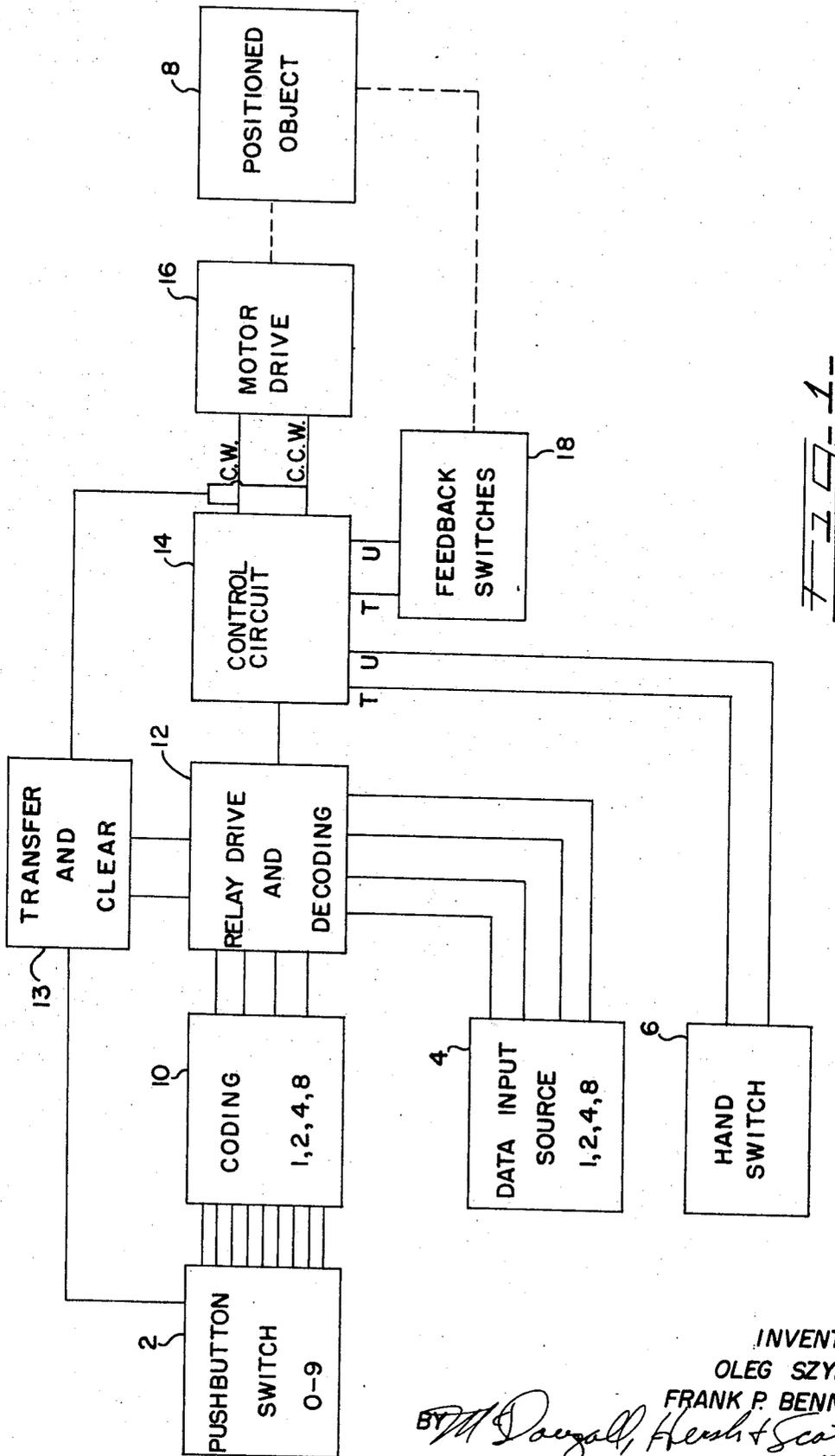
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[57] **ABSTRACT**

A random selection positioning control is shown in which discrete positions for an object such as a photographic slide carrier may be commanded in a random manner from any one of several input sources such as a pushbutton switch, a rotary switch or a remote data source such as a computer or a telephone transmission system. The position of the object to be controlled may be randomly selected while the control circuit includes means whereby the object will travel the shortest distance to the selected position in order to minimize time required for the completion of an operating cycle.

28 Claims, 12 Drawing Figures





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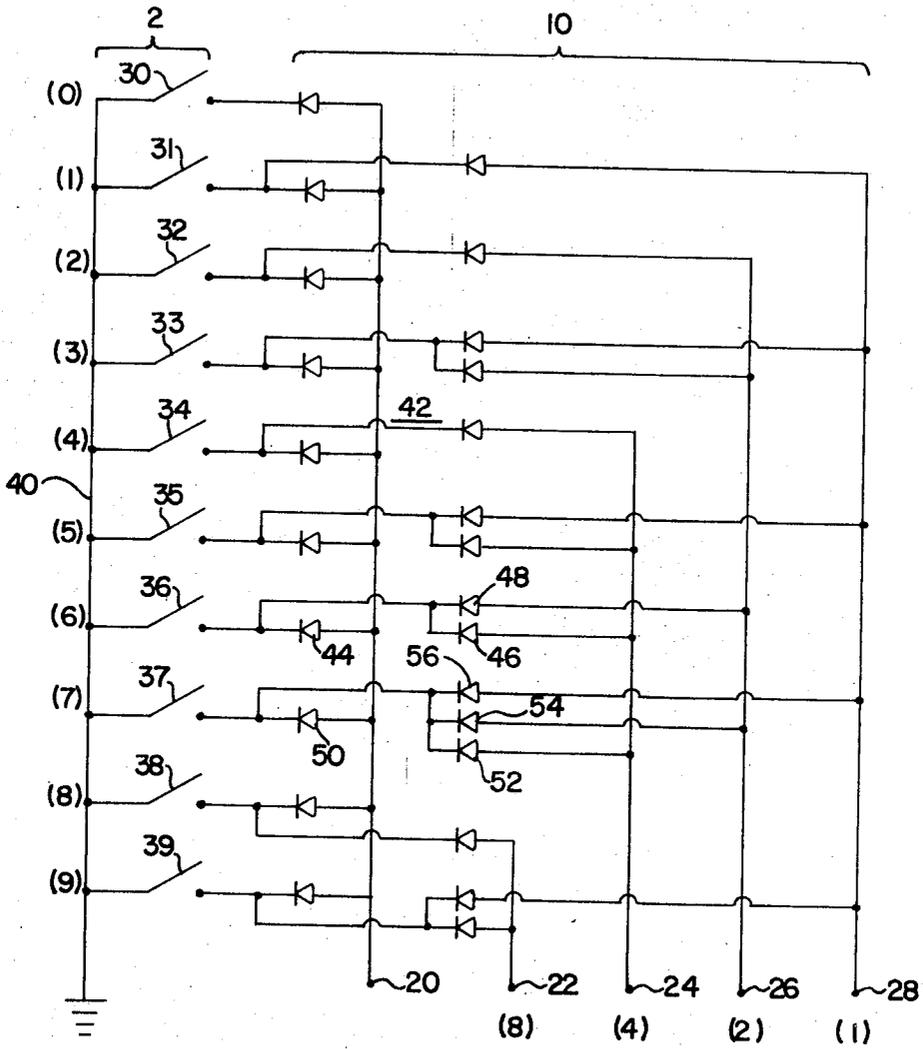
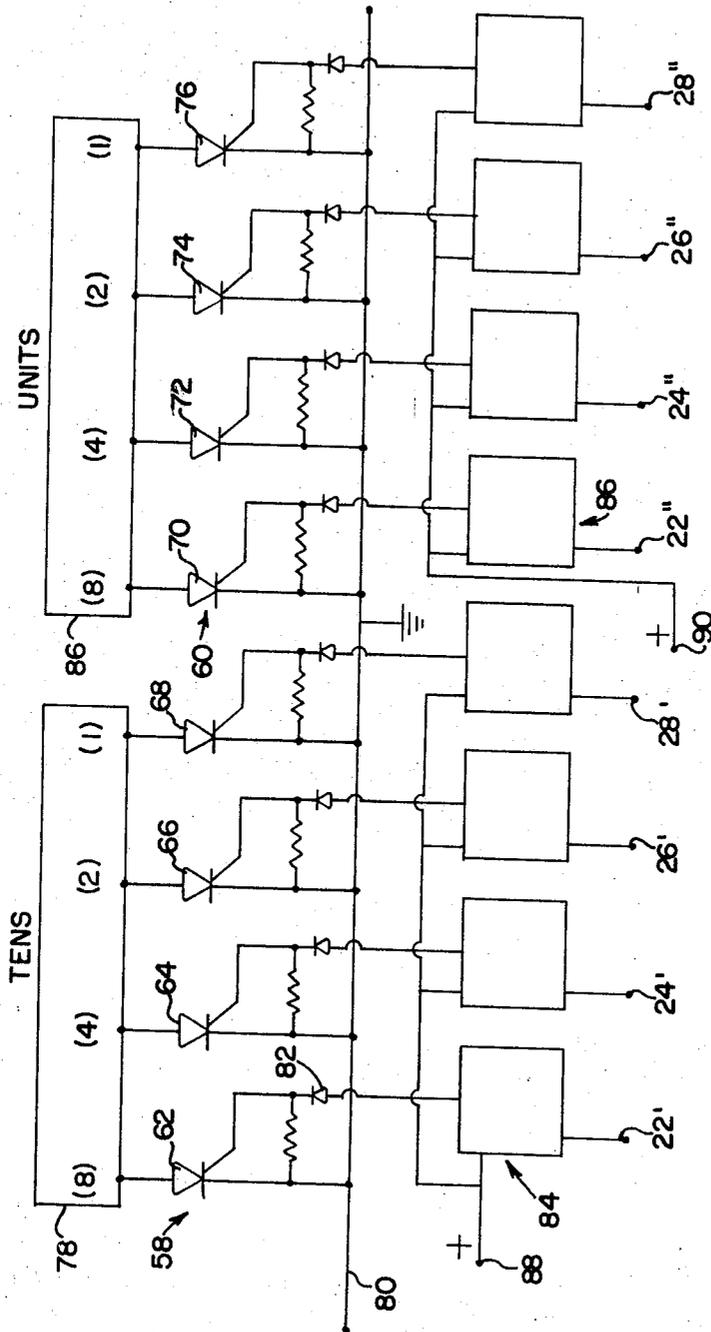


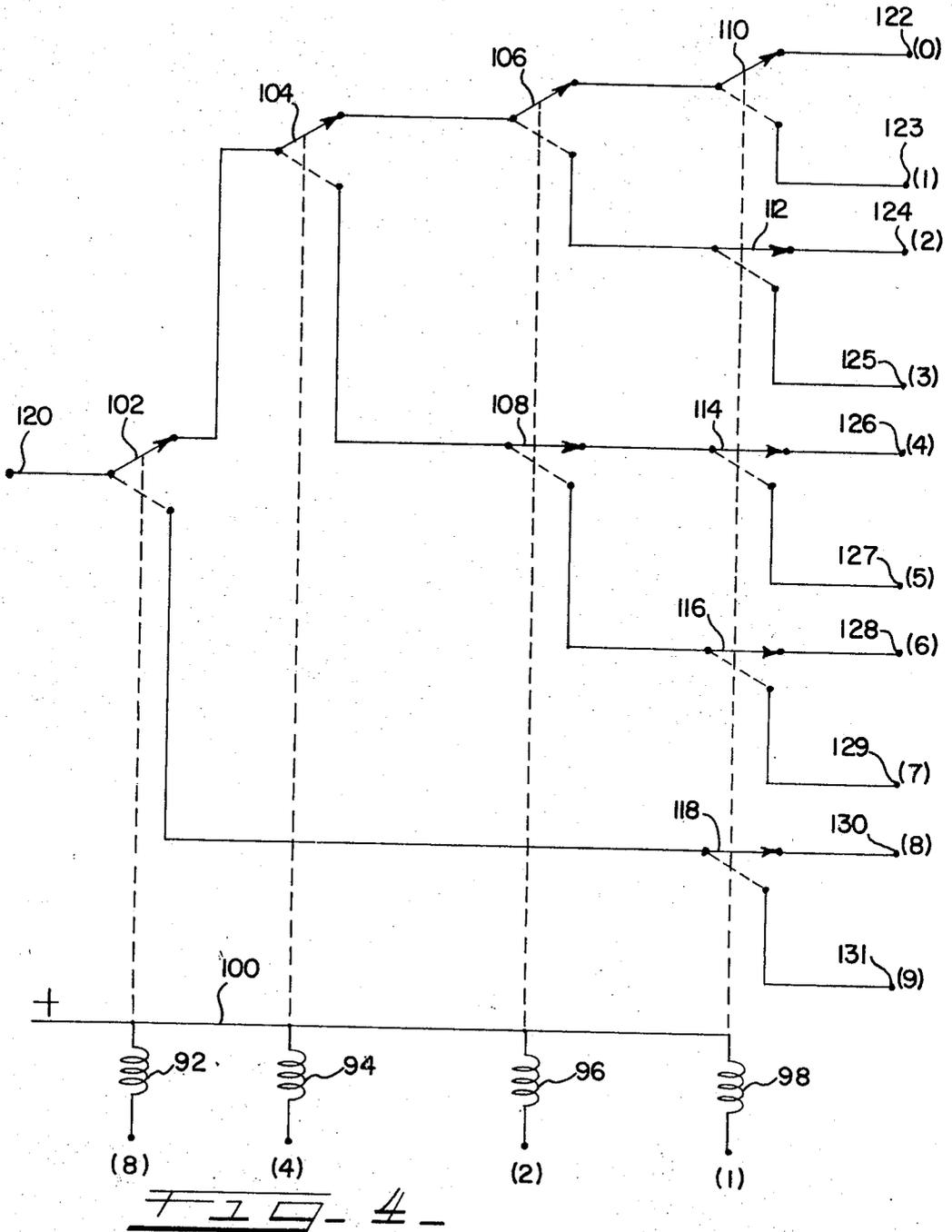
FIG. 2

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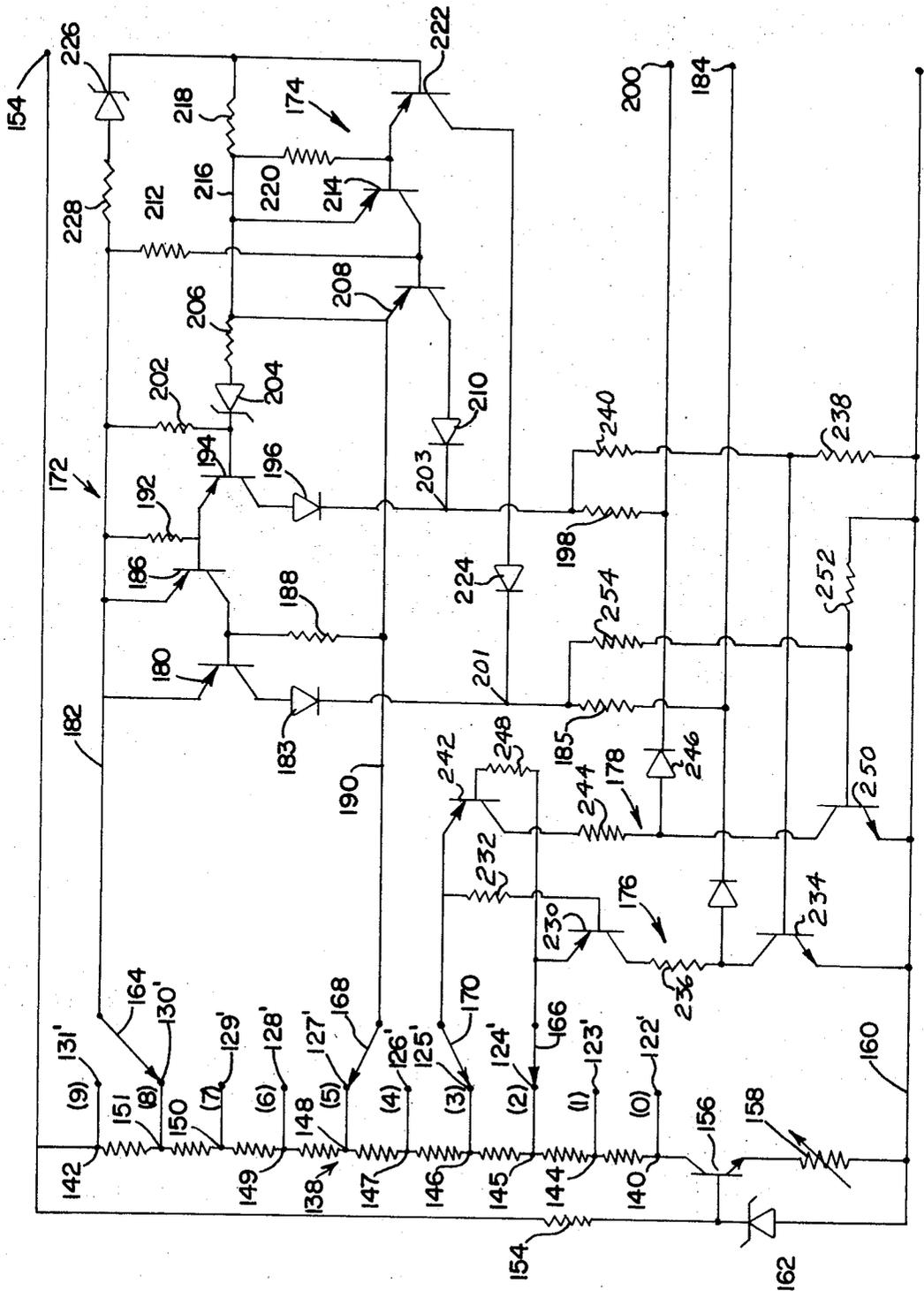


FIG. 5

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FIG. 11

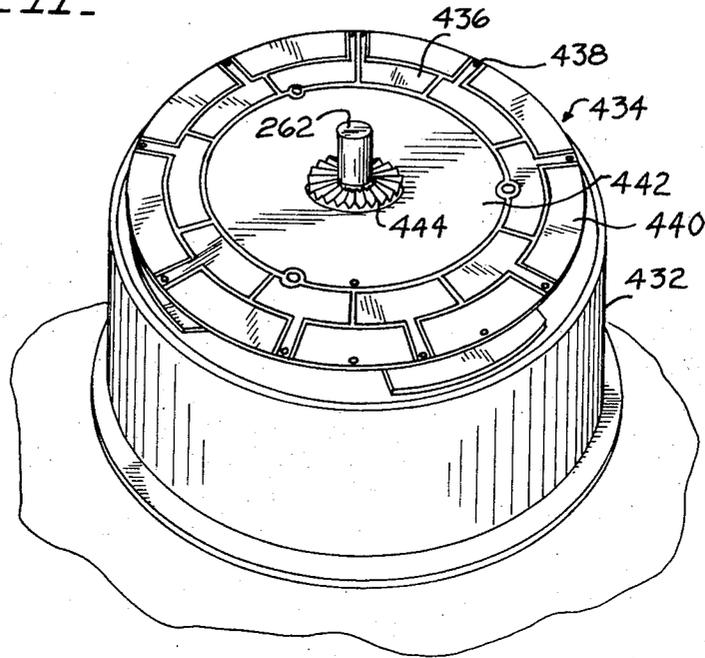
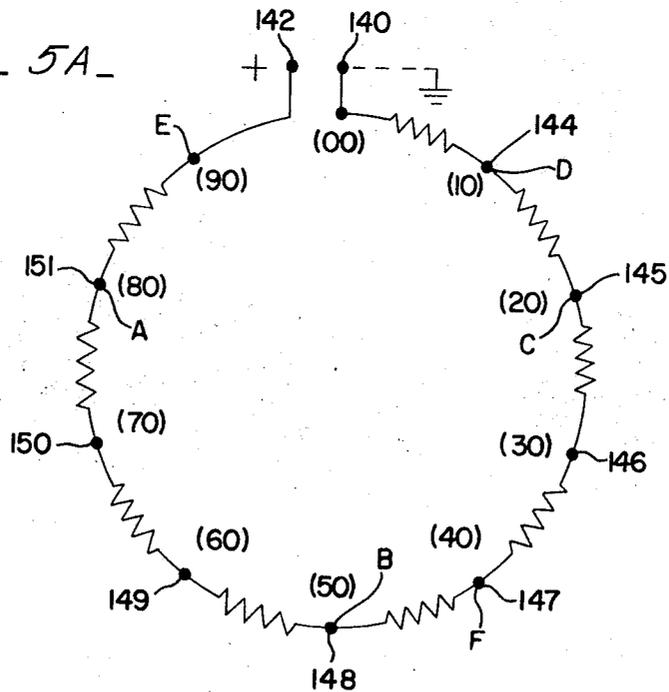


FIG. 5A



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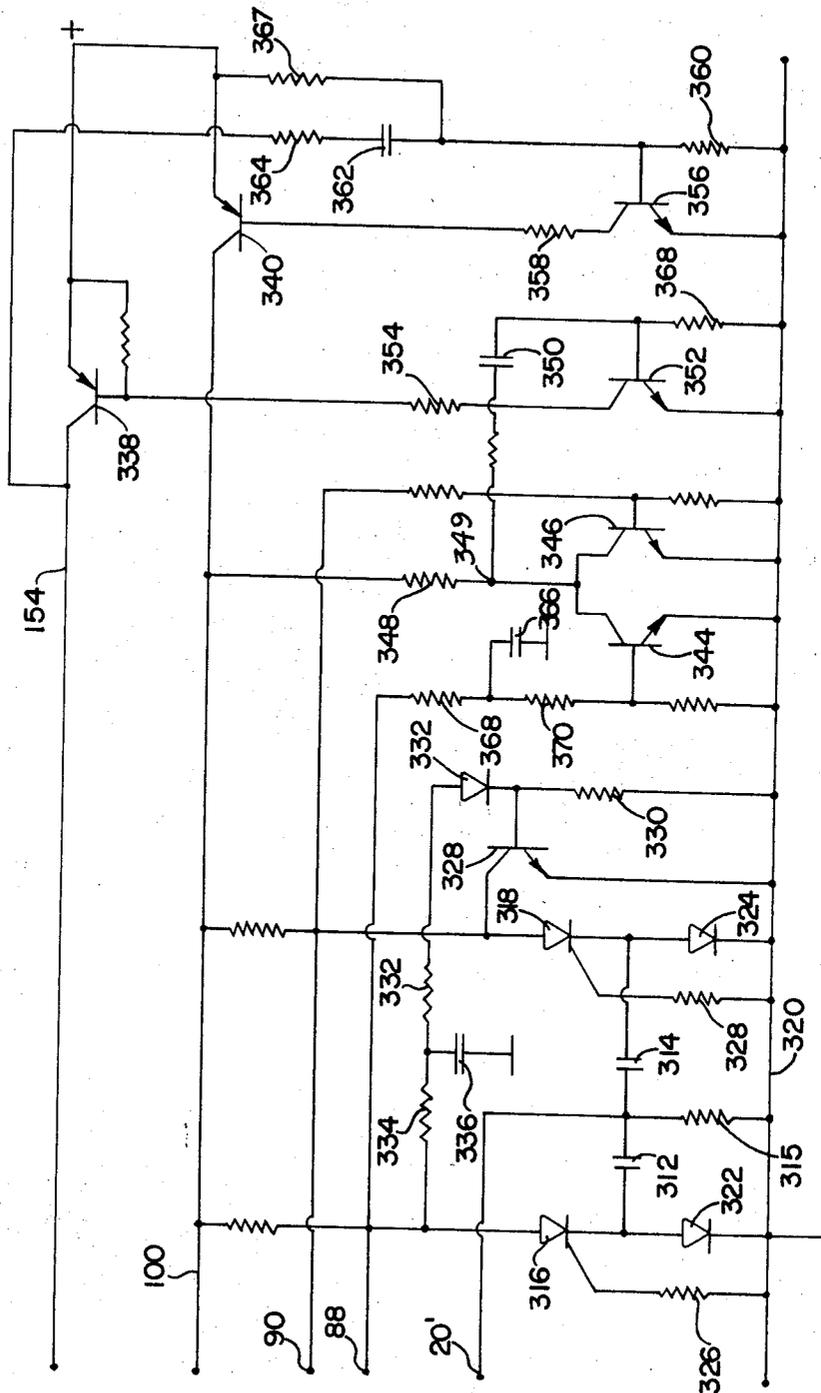


FIG. 7

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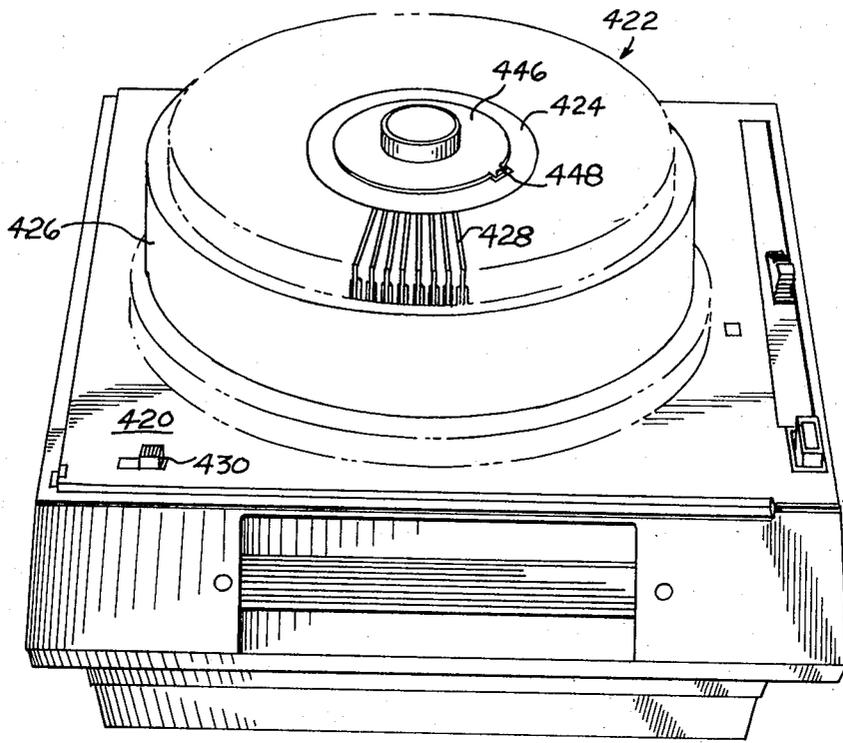


FIG. 9

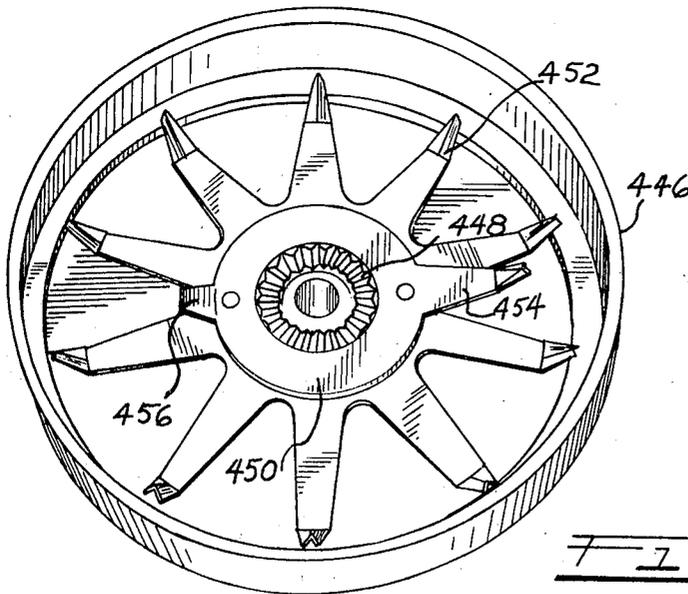


FIG. 10

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RANDOM SELECTION POSITIONING CONTROL SYSTEM HAVING MULTIDIGIT CONTROL SIGNALS

BACKGROUND OF THE INVENTION

This invention relates to improvements in remote control systems. More specifically, it relates to improvements in remote control systems for positioning rotary objects.

Remote control positioning systems are known in which a positioning command is produced by a switch or other command data input and that signal is used to cause a motor to propel an object to a desired position. Such systems have been applied to a number of different types of apparatus and generally are satisfactory. However, with the development of computers and the ability to transmit data over communication lines such as telephone lines or microwave links, it has become desirable to provide a remote control means which is capable of receiving its command information from a number of different sources. For instance, it is desirable to provide such a system which may be operated either from a remote station near the object itself but which also be capable of receiving input command data from a source more remote such as a control in another geographic location or from a programmed source such as a data processing device or a computer. A particular device to be positioned with which a system of this kind has utility, is a slide projector having slide trays carrying a number of slides which when the tray is positioned are fed between a light source and a lens system to be projected. Very often, it is desired to project the slides in a random sequence determined by an operator, that is, a sequence which is different from the sequence in which the slides are inserted into the trays. In other instances, it is desired to project the slides in such a random sequence as determined by a data processing device. In such an application, it becomes economically desirable to provide a control system which is capable of receiving its input data from any one of a number of different sources and it is important to provide such a capability by a means which is accurate, economical and reliable.

Therefore, it is an object of this invention to provide a remote control random selection or positioning system which is capable of operating in response to input commands from any one of several sources.

It is another object of this invention to provide a remote control random selection system for an object to be positioned which is reliable and accurate in its operation.

It is still another object of this invention to provide a remote control system for positioning a rotatable object which insures that the object will travel the shortest path to the desired position.

SUMMARY OF THE INVENTION

These and other objects are achieved by the provision of a remote control system which is capable of operating in response to an input command which is in the form of a decimal number representing the desired position or in the form of a binary coded decimal number representing such a position. A control circuit is included which is capable of selecting which of two paths to the desired position is the shortest and moving the object to be positioned along that shortest path in order to reduce the duration of an operating cycle.

DESCRIPTION OF THE DRAWINGS

The invention itself is set forth in the claims appended hereto and forming a part of the specification. The construction and mode of operation of various embodiments thereof may be understood by the detailed description taken in conjunction with the drawings in which:

FIG. 1 is a block diagram illustration of a system in accordance with the invention;

FIG. 2 is a schematic illustration of a coding network which may be used in the invention;

FIG. 3 is a schematic illustration of a relay drive circuit forming a part of the invention;

FIG. 4 is a schematic illustration of a decoding circuit which may be used in the invention;

FIG. 5 is an illustration of a control circuit forming a part of the invention;

FIG. 5A is a schematic diagram illustrating how an object may be positioned in either a clockwise or counterclockwise direction in response to the control system;

FIG. 6 is a schematic illustration of the motor drive circuit forming a part of the invention;

FIG. 7 is a schematic illustration of a transfer and clear circuit forming a part of the invention;

FIG. 8 is a schematic illustration of a control system in accordance with the invention as applied to a slide projector;

FIG. 9 is a perspective view of a slide projector with which a control system in accordance with the present invention may be used;

FIG. 10 is a perspective view of the underside of a cap member mounted on a central hub of the projector showing feedback switches; and

FIG. 11 is a perspective view of the slide projector hub with the cap of FIG. 2 removed showing the stationary elements of the feedback switches.

DETAILED DESCRIPTION

An overall understanding of a random position selection system in accordance with the invention may be understood by reference to FIG. 1. In this figure, such a system may be arranged to receive input data in numerical form from any one of several sources representing the desired position of an object. For instance, such a source could be constituted by a push button switch means 2 having a series of switches representing the digits 0 through 9. A common switch means of this type is provided on telephone instruments of the push-button variety. When such a means is used, it could be in the immediate vicinity of the object to be positioned or it could be at a remote geographic location and operated there with the data input produced remotely and transmitted via telephone communication links and data handlers to the control system. An example of the usage of this type of system is when it is desired to project slides at a remote location and accompany the projection of such slides with an oral description of the scene being projected. The user could provide a voice transmission over the telephone and at the same time by operating the push buttons on his telephone set select the slides to be projected and accompany his oral presentation.

Another source for command data input could be a data processing device 4 in which the sequence of positions is determined in accordance with some program or computation determined by the data processor. An example of this usage would be in a hotel, motel or travel reservation system where it was desired to display in a remote location the accommodations available as indicated by the memory of the data processor.

Still another input could be a hand switch 6 to be operated by a user in the immediate vicinity of the positioned object to randomly select the positions desired. Again, in the context of the application of the system of this type to a slide projector, this would permit the random selection of slides arranged in a predetermined sequence in a tray.

Reference numeral 8 designates the object to be positioned. As indicated, this may be constituted by a rotatable tray forming a part of a slide projector. A very common capacity of such a tray is up to 100 slides. Therefore, in one embodiment of the invention it would be desired to position the object to any one of 100 positions which may be numbered sequentially 0 through 99. These numbers are in decimal form because the average person has the greatest familiarity with this kind of numbering system. Therefore, if the data input is in some other numbering system, appropriate coding and decoding circuits are provided in order to produce electrical signals which represent or command the desired position according to their decimal values. Thus, when a pushbutton switch 2 is used, the

output is constituted by a plurality of identical voltage values but which represent different digits in a decimal number depending upon the output terminal on which they appear. A coding circuit 10 is provided which receives as an input the output of the pushbutton switch 2 and supplies its output in turn to a relay drive and decoding circuit 12. The coding circuit 10 produces as its output electrical signals representing a binary coded decimal number so that the input command in that form must be converted to a straight decimal number before it is supplied to a control circuit 14.

The relay drive and decoding circuit may also receive as an alternative input a command number already in binary coded decimal form from the data input source 4 and convert that number to a straight decimal for application to the control circuit.

When a hand switch 6 is used, no coding or decoding is necessary if the hand switch is marked off in straight decimal numbers and the input command produced by the hand switch 6 may be supplied directly to the control circuit.

The control circuit 14, therefore, receiving as its input electrical signals representing the desired position in straight decimal form will produce electrical analogs, voltages as shown in the embodiment described and will also receive as another input signals or voltage analogs representative of the actual position of the object to be positioned and will effect a comparison between those two signals in order to produce a difference signal which is supplied to a motor drive 16 effective to position the object in accordance with the input command. The motor drive circuit has its output element mechanically connected to the positioned object 8 and causes it to move to the desired position in a direction depending upon whether the control circuit has determined that it should move in a clockwise or counterclockwise direction. Mechanically connected to the positioned object 8 is a feedback means 18 such as switches which are moved along with the positioned object in a direction so as to reduce the difference signal produced by the control circuit to zero at which time the positioned object stops. At this point in the case of a slide projector, the mechanism for feeding a slide into the viewing position may then be operated and the slide projected.

In order to preclude the insertion of a new position command while the object 8 is being driven to a desired position and to clear the relay drive circuit for the receipt of a new command after a previously commanded position has been reached, a transfer and clear circuit 13 receives as one input the output signals of the control circuit 14. If such output signals are present indicating that the object is in motion then the circuit will prevent the relay drive and decoding circuit 12 from receiving any new command signals until the output of control circuit 14 goes to zero. In addition, the circuit 13 functions to transfer the signals representing the input digital command so that the first signal received is treated as the tens digit and the second as the units digit in a two digit decimal number. Thus, one of its outputs is to the relay drive and decoding circuit 12.

FIG. 2 of the drawing illustrates schematically a coding network 10 and a pushbutton switch 2. The coding network is provided with five output terminals 20, 22, 24, 26 and 28. The terminal 20 has a signal appearing thereon which is effective to command a zero in either the tens or units digit position and to effect an initiation of a cycle of operation as will be explained hereinafter. In the particular arrangement illustrated, the binary code utilized is a 8, 4, 2, 1 code so that the terminals 22, 24, 26 and 28 are assigned those values, respectively.

The pushbutton switch 2 is provided with 10 normally open switches 30 through 39, the movable contacts of which are connected to a common grounded bus 40. The stationary contacts of the switches are connected to various diodes 42 in the decoding network 12. Inasmuch as the various circuits from the stationary contacts to the output terminals are similar and can be easily followed only two examples of the operation will be described. It is to be noted that in the illustrated embodi-

ment the actual signal representing a digit or initiating a function is actually a zero value of voltage in accordance with usual practice in the data processing art at this time. However, this is a matter of choice for signals having values other than zero either positive or negative could be used. Thus, when one of the switches 30 through 39 is closed, the result is to connect one or more of the terminals 20, 22, 24, 26 or 28 to the common ground bus 40 to complete a circuit in the relay drive 12 as will be explained hereinafter.

The operation of this portion of the system can be understood by following the circuit when one of its switches 30 through 39 is closed to select the decimal number (6) for instance. In this case, the operator closes switch 36 and a circuit is completed from the bus 40 through a diode 44 to the terminal 20. Since the operator wishes to command a (6), the terminal 20 functions only to initiate a cycle of operation. At the same time a circuit is completed through the diodes 46 and 48 to the terminals 24 and 26, respectively. These terminals have the binary code values (2) and (4) assigned to them and thus together represent a decimal (6). Likewise, if the decimal number 7 is desired, the switch 37 is closed completing a circuit for the terminal 20 as before and through the diodes 52, 54 and 56 to the terminals 24, 26 and 28 which have the binary code values of (4), (2) and (1), respectively, which add up to decimal (7). If a decimal (0) is desired, the switch 30 is closed and the terminal 20 is connected to the bus 40 to provide an initial signal but as may be seen none of the other terminals, 22, 24, 26 and 28, are connected so there is no decimal value other than zero. In a similar manner, operation of any of the other switches 31, 32, 33, 34, 35, 38 or 39 will connect corresponding ones of the terminals 22, 24, 26 or 28 to the bus 40 to provide a binary coded representation of the decimal numbers 1, 2, 3, 4, 5, 8 or 9.

The output of the coding network 10 is connected to the input of the relay drive and decoding circuit 12. This latter circuit functions to control the energization of a plurality of electromagnetic relays which provide a decimal analog input to the control circuit representing the position desired. The relay drive circuit as shown in FIG. 3 comprises two groups of SCRs 58 and 60, one for the tens digits, the other for the units digits in the decimal numbers 0 through 99. The first SCR group 58 comprises SCRs 62, 64, 66 and 68, the anodes of which are connected in series with the corresponding coils of an equal number of electromagnetic relays in a tens decoding circuit 78. The cathodes of each SCR are connected to common ground bus 80 while their gate electrodes are connected through protective diodes 82 to associated firing circuits 84. The second group 60 of SCR's 70, 72, 74 and 76 are connected to electromagnetic relays in a units decoding circuit 86, the bus 80 and associated firing circuits 86 in the same fashion.

The tens firing circuits 84 are provided with input terminals 22', 24', 26' and 28' which are connected to the corresponding output terminals 22, 24, 26 and 28 of the coding network 10 as are the input terminals 22'', 24'', 26'' and 28'' of the firing of the units firing circuits 86. As described previously, the control signals are digital in nature where the presence of a signal or "1" is indicated by the presence of zero voltage while its absence or "0" is indicated by a positive value. In accordance with this, the firing circuits 84 and 86 are selected to be inverters so that they will provide at their outputs the positive signal necessary to fire the SCR to which they are connected. Further, since it is desired to use only one set of pushbuttons 0 through 9 the firing circuits are connected so that one set is enabled at a time. This is effected by providing a power supply terminal 88 for the firing circuits 84 and a separate such terminal 90 for the firing circuits 86 and by sequentially supplying power to those firing circuits. Thus, the first depression of a push button will cause a tens digit to be entered and fire one or more of the SCRs 62, 64, 66 or 68 and the second depression of a pushbutton will enter a units digit and fire one or more of the SCRs 70, 72, 74 or 76.

A relay decoder useful in this embodiment of the invention is illustrated in FIG. 4. Inasmuch as the decoder for the tens and units digits are identical to that shown in FIG. 4, the following description may be taken for both. Each decoder comprises four electromagnetic relays 92, 94, 96 and 98 assigned to binary coded numbers (8), (4), (2) and (1), respectively. One end of each relay winding is connected to a common positive bus 100 while the other ends of their windings are connected separately to the anodes of corresponding SCRs. Relay 92 has a single contact 102 which when the relay is deenergized is in the solid line position shown. Relay 94 has a contact 104 illustrated in its deenergized state by the solid line position of the contact. Likewise, relay 96 has a pair of contacts 106 and 108 similarly illustrated as are the contacts 110, 112, 114, 116 and 118 of relay 98. Output terminals 122 through 131 are provided for the decimal digits 0 through 9 and are connected through stationary contacts of the relays to a terminal 120 as shown.

The operation of the pushbutton switch, coding network, relay driver and decoder is as follows. If it is assumed that the operator desires to command position "05" he first depresses switch 30 closing it to cause an initiate signal to appear at terminal 20. This signal is applied in a manner to be explained hereinafter. Since the tens digit is zero, no signal appears at any of the terminals 22, 24, 26 or 28.

With no signals at their terminals, none of the firing circuits, even though they are enabled by the application of supply voltage to the terminal 88, will cause conduction of any SCR in the group 58 so the relays in the decoder 78 remain deenergized. Consequently, a circuit may be traced from terminal 120 through contacts 102, 104, 106 and 110 to output terminal 122 for the decimal digit (0). The operator then depresses switch 35 causing signals to appear at terminals 24 and 28. By virtue of the operation of the transfer and clear circuit 13, the firing circuits 84 which had been previously enabled by the application of a supply voltage have now been disabled while the firing circuits 86 are enabled. This causes the SCRs 72 and 76 to fire energizing relays 94 and 98 in the decoder. Relay 94 when energized actuates contact 104 to its dotted line position and relay 98 similarly actuates contacts 110, 112, 114, 116 and 118 to their dotted line positions. When so actuated, a circuit may be traced from terminal 120, contact 102-solid line, contact 104-dotted line, contact 108-solid line, and contact 114-dotted line to output terminal 127 which has the assigned value of decimal number 5.

If the position desired has been "55," the operator would first depress switch 35 to provide an initial signal and a signal at terminals 24 and 28 as described above. This signal representing to tens digit (5) would have been effective to energize relays 94 and 98 as before but in the decoder 78 rather than in the decoder 86. The next operation of the switch 35 would have energized the relays 94 and 98 in the units decoder 86.

As described above, the input command appearing at the terminals 122 through 131 can also be produced by signals from a data input source 4 or a hand switch 6. When a data input source is used, the command already in binary coded decimal form need not be coded but supplied as input to the circuit 12, will be translated to a decimal number at the terminals 122 through 131 and supplied to the control circuit 14. A command from the hand switch 6 which in the illustrated embodiment is a 100 position switch is supplied directly to the control circuit 14.

Referring to FIG. 5, the control circuit 14 includes a voltage divider 138 comprising a plurality of resistors effective to provide voltage analogs of the desired and actual position, each of the same resistance value and having a plurality of terminals 122' through 131' connected to the ends 140 and 142 of the divider and the junction points 144 through 152 of the resistors. A positive voltage supply bus 154 supplies voltage to the divider which voltage is held substantially constant by a series regulator comprising an NPN-transistor 156 connected with its collector and emitter in series between the end point

140 and an adjustable resistor 158 connected in turn to a common bus 160. The regulator further comprises a zener diode 162 connected to the common bus and through a dropping resistor 164 to the positive bus 154. The cathode of the zener diode is connected to the base of transistor 156 so that in the event applied voltage at that cathode exceeds the inverse voltage characteristic of the zener it will conduct maintaining the voltage between the base of transistor 156 and bus 160 constant. Because the voltage at the base of transistor 156 is constant its emitter to ground voltage is also constant and when the value of resistor 158 is adjusted a constant current flows through the divider 138.

In order to provide an indication of the position of the object 8 at any time, a pair of movable contacts 164 and 166 are mechanically connected to the object in a manner to be described hereinafter so as to be driven thereby and make electrical contact with any one of the terminals 122' through 131'. The contact 164 is arranged to provide an indication of "tens" position of the object while the contact 166 provide an indication of its "units" position in a system where any one of 100 positions designated 0 through 99 may be possible.

The input to the control circuit representing the desired or commanded position is provided by contacts 168 and 170. As may be seen in FIG. 5, if the contacts 164 and 166 indicating the actual position of object 8 are in electrical connection to any of the terminals 122' through 131' with which the contacts 166 and 170 are not in electrical contact, a potential difference will appear between the contacts 164 and 168 constituting an electrical analog representation of the difference between the desired position and the actual position expressed in the tens digit. Likewise, if contacts 166 and 170 are in electrical contact with different ones of the terminals 122' and 131', the potential difference therebetween is an electrical analog representation of the difference between desired and actual position expressed in the units digit.

The remainder of the control circuit 14 compares the voltage analogs of the desired and actual positions and utilizes the difference, if any, between the switches 164 and 168 and 166 and 170 to produce a difference signal to control motor means to move the object 8 toward the desired position. The means for doing this comprises a first transistor circuit 172 responsive to the difference of tens digits contacts 164 and 168 to supply a signal causing object 8 to move in a clockwise or counterclockwise direction when the difference is such that potential at contact 164 is higher than that at contact 168. A second transistor circuit 174 is connected to provide a signal to cause the object 8 to move in a clockwise or counterclockwise direction when the relationship of contacts 164 and 168 is such that the potential at contact 168 is higher than that at contact 164. In this manner, the shortest path to the commanded position is selected regardless of the relative position of the contacts. A third transistor circuit 178 responsive to any difference in the position of the units digit contacts 166 and 170 provides a clockwise signal for moving the object 8 in a counterclockwise direction while a fourth transistor circuit 178 provides a signal for units motion in the clockwise direction.

The circuit 172 comprises a PNP-transistor 180 having its emitter connected to conductor 182 connected to the terminal of switch 164. The collector of 180 is connected through a diode 183 and a load resistor 185 to an output terminal 184 at which it appears when appropriate, a signal directing movement in the counterclockwise direction. The base of transistor 180 is connected to the collector of a second PNP-transistor 186 and through a biasing resistor 188 to a conductor 190 connected to the terminal of switch 168. The emitter of transistor 186 is connected to the conductor 182 and its base is connected through resistor 192 to conductor 182 and to the emitter of a third PNP-transistor 194. Transistor 194 has its collector connected through a diode 196 and a resistor 198 to conductor connected at a clockwise output signal terminal 200. The base of transistor 194 is connected through limiting resistor 202 to conductor 182 and through a zener diode 204 and resistor 206 to conductor 190.

The second transistor circuit 174 comprises a PNP-transistor 208, the emitter of which is connected to conductor 190 while its collector is connected through a diode 210 and resistor 198 to clockwise output terminal 200. The base of transistor 208 is connected through a resistor 212 to conductor 182 and to the collector of a PNP-transistor 214. Transistor 214 has its emitter connected to a conductor 216 connecting resistor 206 with a resistor 218 and its base is connected to the junction of a resistor 220 and the emitter of a PNP-transistor 222. The collector of transistor 222 is connected through a diode 224 to resistor 185 while its base is connected through a zener diode 226 and a resistor 228 to conductor 182. As may be seen, the counterclockwise output signal supplied as a result of the conduction of either transistor 180 or 222 appears at the junction point 201, while the clockwise output signal supplied as a result of the conduction of either transistor 194 or 208 appears at the junction point 203.

Transistor circuits 172 and 174, as shown, operate alternately to provide clockwise and counterclockwise signals depending upon the relative positions of the contacts 164 and 168. This may be understood by reference to FIG. 5A in conjunction with FIG. 5. FIG. 5A illustrates ten possible positions (00) through (90) of the rotatable object 8. These positions are those designated by the tens units in a two digit number. If the object 8 as assumed to be at the position (80) as shown by reference character A in FIG. 5A and it is desired that it move to position number (50), reference character B in FIG. 5A, the contacts 164 and 168 are at the positions shown in FIG. 5, that is, in contact with the terminals 130' and 127', respectively. Thus, contact 164 is in electrical contact with junction 151 while contact 168 is in electrical contact with junction 148. If it is assumed that the voltage drop across each resistor in the divider is 2.4 volts and the inverse voltage characteristic of the zener diodes 204 and 226 is 12 volts, then the operation of the circuit is as follows. As may be seen in FIG. 5A, the shortest distance between points A and B is in the counterclockwise direction so it is desired to move in that direction in order to reduce the time required for the completion of a cycle of operations. Under these circumstances, the transistor circuit 172 is rendered operative. This is accomplished because the voltage at junction 151 is 7.2 volts higher than that at junction 148. Therefore, the base of transistor 180 is negative with respect to its emitter and that transistor will conduct producing a signal at the counterclockwise output terminal 184 which will be effective to cause the positioned motor to drive the object 8 in a counterclockwise direction from point A toward point B. Since the contact 164 is mechanically connected to the object 8, it will move with it until it is in electrical contact with terminal 127' and junction 148 at which time the voltage difference between the contacts 164 and 168 and therefore the conductors 182 and 190 is zero and transistor 180 will turn off removing the signal from terminal 184. During this interval of operations, no signal is applied to the clockwise terminal for the following reasons. With the values assumed, that is, the zener diode 204 is selected to have the inverse voltage characteristic of 12 volts and with the contacts 164 and 168 in the position illustrated the inverse voltage applied is equal to three times 2.4 or 7.2 volts so that the diode is not conducting in the reverse direction. Under these circumstances, the base of the transistor 194 is zero with respect to its emitter so that it is nonconducting and no signal will be applied from that transistor to the clockwise output terminal 200. At the same time the transistor 208 with its emitter connected to the conductor 190 and its base connected to the conductor 182 is held off by virtue of the relative voltages and it too will not apply any signal to the clockwise output terminal 200.

If it is desired to move the object 8 from the position A shown in FIG. 5A to a position C shown in that figure where the contact 168 is in electrical contact with the terminal 124' and junction 145, it may be seen that the shorter path between points A and C is in the clockwise rather than the counterclockwise direction. Under these circumstances, there are six

resistor units between the contacts 164 and 168 and with an assumed voltage of 2.4 volts per unit the voltage differences is 14.4 volts. This voltage applied across the zener diode 204 exceeds its inverse voltage characteristic of 12 volts and that diode will conduct. When it conducts, the base of transistor 194 will go negative with respect to its emitter and that transistor will conduct applying a signal to the clockwise output terminal 200 to cause the object 8 to move in the clockwise direction. When the transistor 194 conducts, its emitter provides the base current for transistor 186 and turns it on. When transistor 186 conducts, its collector will shunt the base of 180 turning it off so that no signal will be applied by that transistor to the counterclockwise output terminal 184.

The transistor circuit 174 operates in the same manner except that it is effective to provide control when the contact 164 and conductor 182 are connected to one of the terminals 122' through 131' such that the voltage applied thereto is less than the voltage applied to the conductor 190 as determined by the position of the contact 168. This occurs when the potential at contact 168 is higher than the potential or more positive than the potential at contact 164. Again referring to FIG. 5A, this situation can occur if the object 8 were at position (10) reference character D and it were desired to move the object to (90), reference character E. Under these circumstances, the contact 164 will electrically contact terminal 123' and junction 144 while contact 168 will electrically contact terminal 131' and junction 142. As may be seen from FIG. 5A, the shortest distance between the points D and E is in the counterclockwise direction. Under these circumstances, the transistor circuit 172 will be maintained in an off condition since the base of transistor 180 will be positive with respect to its emitter as will the base of transistor 194. The inverse voltage across zener diode 226 will be greater than the inverse voltage characteristic of that diode and it will conduct turning on transistor 222 which will be effective to supply an output voltage at the counterclockwise output terminal 184 to cause the object 8 to move in the counterclockwise direction from point D to point E. When transistor 222 conducts, it turns on transistor 214 and turns off 208. If it were desired to move the object 8 to position (40), reference character F in FIG. 5A, as before, the voltage on conductor 190 would be higher than that on 182 but at a value less than the inverse voltage characteristic of zener diode 226. Under these circumstances, transistors 222 and 214 are maintained in an off condition while transistor 208 conducts applying an output signal to the clockwise output terminal 200.

Thus, the circuits 172 and 174 function in an alternative manner to effect motion of the object 8 depending on whether or not it is to be moved in a clockwise or counterclockwise direction in order to travel the shortest path to a desired point and depending on the relative positions of contacts 164 and 168.

As pointed out, the two circuits 172 and 174 are effective to provide positioning signals in response to the tens digit information. In order to provide signals in response to the units digit information in the two digit decimal number, the transistor circuits 176 and 178 are provided. The transistor circuit 176 comprises a first transistor 230 having its emitter connected to contact 166 and its base connected through a resistor 232 to contact 170. A second transistor in the circuit 176 is an NPN-transistor 234 having its collector connected through a resistor 236 to the collector of transistor 230. The emitter of transistor 234 is connected to the bus 160 while its base is connected to the junction of a pair of resistors 238 and 240, the ends of which are connected to the bus 160 and to the collector circuits of the transistors 194 and 208.

The fourth transistor circuit is similar comprising a PNP transistor 242 with its emitter connected to the contact 170 while its collector is connected to the resistor 244 and diode 246 to the clockwise output terminal 200. The base of the transistor 242 is connected through resistor 248 to the contact 166. A second transistor 250 of the NPN-variety has its collec-

tor connected to the junction of the resistor 244 and diode 246 while its emitter is connected to the bus 160. The base of the transistor is connected to the junction of resistors 252 and 254 while the ends of the resistors are connected, respectively, to the emitter circuits of the transistors 180 and 222 and the bus 160.

The operation of this circuit is such that during a positioning cycle the positioning signals appearing at the terminals 184 or 200 are effective first to cause positioning of the object 8 to the position commanded by the position of the tens digit contact 168 and to then position the object to the position commanded by the units digit contact 170. As may be seen, the counterclockwise tens output signal appears at the terminal 201 while the clockwise tens output signal appears at the terminal 203. The counterclockwise positioning signal at the junction 201 in addition to appearing at the output terminal 184 is also supplied to the base of transistor 250 causing it to conduct when such a signal is present. The conduction of that transistor acts to shunt any signal which may be present as the result of the conduction of transistor 242 to ground, so that no clockwise positioning signal will be present at the terminal 200. In a similar fashion the clockwise positioning signal appearing at the junction 203 is supplied to the base of the transistor 234 causing that transistor to conduct if such a signal is present in response to a difference between the desired position and the actual position in the "tens" decade. The circuit arrangement is such that if there is a "tens" positioning signal, it will function to prevent either of the circuits 178 or 176 from supplying a positioning signal to the terminals 184 or 200 which is opposite in direction. When the object has moved to the position commanded by the position of the contact 158 and none of the transistors in the circuits 172 and 174 are conducting, the transistors 250 and 234 will revert to a nonconducting state, and under these circumstances, one or the other of the transistors 230 or 248 may conduct.

In FIG. 5, the switch 166 is shown in electrical contact with the terminal 124' and therefore the junction 145 while the contact 170 is shown in electrical contact with the switch 125' and therefore the junction 146. Under these circumstances, the base of the transistor 242 is negative with respect to its emitter and inasmuch as this indicates that in order for the object to advance from position (2) to position (3), it should move in a clockwise direction, the transistor 242 will conduct applying a positioning signal to the clockwise output terminal 200 which signal will remain and be effective to cause clockwise rotation of the object 8 until the contact 166 is in electrical contact with the same terminal as the contact 170. Were the contacts 166 and 170 to be reversed, that is, with the contact 166 in electrical contact with the terminal 125' and the contact 170 in electrical contact with the terminal 124', the transistor 242 would be held off inasmuch as its emitter was positive with respect to its base while the transistor 230 would conduct applying an output signal to the clockwise output terminal 184.

In summary, the control circuit 14 is effective to provide positioning signals, which first position according to the tens digit input command and then position according to the units digit input command and the positioning signals provided are effective to cause a rotatable object to move in the shortest direction toward the desired position.

It should be understood that output terminals 122 through 131 of the decoders 78 and 86 correspond electrically with terminals 122' through 131' of the divider 138. Thus, with respect to the "tens" decoder 78, a circuit from terminal 120 to any one of the terminals 122 through 131 is the same as a circuit from the conductor 190 through switch 168 to the corresponding one of the terminals 121' through 131'. Likewise, with respect to the units digit decoder 86, the same relationship exists and the terminal 120 represents the conductor connected through the switch 170 to the terminals 121' through 131'. Thus, the switches 168 and 170 are symbolic representations of the contacts of the relays 92, 94, 96 and 98.

In order to effect positioning of the object 8 in response to positioning signals appearing at the terminals 184 and 200, the motor circuit 16 shown in FIG. 6 may be provided. A motor 260 having a rotatable shaft 262 is supplied from the secondary 264 of a transformer, the primary of which (not shown) is connected to a suitable source of AC supply. The motor terminals are connected on one side through the winding 264 to the anode of an SCR 266 having its cathode connected to a ground bus 268. A diode 267 shunts the SCR 266 in the reverse direction. The other terminal is connected through a relay contact 270 to the anode of a SCR 272 having its cathode connected to the bus 268. A diode 273 shunts the SCR 272 in the reverse direction. The terminals 184 and 200 constitute the control of positioning signal inputs to the circuit 16. Terminal 200 is connected to the base of an NPN-transistor 274 having its collector connected to positive supply bus 154 and its emitter connected to the base of another NPN-transistor 276. The collector of transistor 276 is connected to the operating coil of a relay 278 and its emitter to the bus 268. The collector of transistor 274 is also connected to the gate electrode of SCR 266 so that when transistor 274 is off SCR 266 will conduct whenever its anode is positive with respect to its cathode.

Terminal 184 is connected to the base of an NPN-transistor 280 having its collector connected to the positive supply bus 154 and to the gate electrode of SCR 272 and its emitter is connected to the base of transistor 276 and bus 268. With the arrangement described to this point, the motor drive circuit will cause the motor 260 to rotate in a clockwise or counterclockwise direction depending on which SCR 266 or 272 is conducting in response to the presence of control signals at either terminal 184 or 200.

In order to increase the ability of the control to position object 8 accurately to a desired position, a fine positioning control 284 is provided. Such a control might have particular utility when the system is applied to a slide projector as it is important that a slide holder on a slide tray be aligned accurately with the slide feeding mechanism so that a slide may be fed from the tray to a position between the lens and the lamp to permit its projection. The fine positioning control comprises a stationary contact 286 connected to a stationary contact 288 of the relay contact 270. It further includes a pair of spaced stationary contacts 290 and 292 each connected through oppositely poled diodes 294 and 296, respectively, to bus 268. Connected to the motor shaft 262 and movable therewith are a pair of bridging contacts 298 and 300. The motor drive circuit is completed by a manually operated initiate switch 302 in the bus 154 and a normally open contact 304 of the relay 278. The relay 278 also operates the contact 270 which engages the contact 288 when the relay is deenergized and a stationary contact 306 when the relay is energized.

In response to the presence of signals at the terminals 184 or 200 the motor drive operates as follows to position object 8. If it is assumed that the signal is present at terminal 200 so that the desired motion is in the clockwise direction, the base of transistor 274 is positive and will conduct when voltage is applied to its collector. This is done by momentarily closing initiate switch 302 so that such voltage is applied to that collector as well as the collector of transistor 280 and to the series circuit consisting of transistor 276 and relay 278. With a signal at the terminal 200 but not 184 transistor 274 will conduct but 280 will not. With the conduction of transistor 274, the transistor 276 is caused to conduct. The conduction of transistor 276 causes relay 278 to pick up operating contacts 270 and 304. Contact 304 when closed will complete the positive voltage supply to the relay 278 and transistors 274 and 280 to constitute a holding circuit so that initiate switch may be released but operating voltage maintained as a signal is present at terminal 200. When voltage is initially applied by the closing of switch 302, the collector voltage of transistor 274 drops immediately as it is in a conducting state. On the other hand, voltage at the collector of transistor 280 remains high and is supplied to the gate electrode of SCR 272 to cause

it to conduct when its anode is positive with respect to its cathode as it is on every other half-cycle of the alternating current supplied from the transformer secondary 264. Thus, the motor 260 will be supplied by half-cycles of alternating current causing it to move the object 8 in the clockwise direction. As the motor rotates, it will drive the object toward the position desired as indicated by the positions of switches 168 and 170 as determined by the input command and will move switch 164 toward switch 168 and switch 166 toward switch 170. When these switches are in contact, there will be no further signal at terminal 200 and transistor 274 will cease conduction, turning off transistor 276 so that relay 278 is deenergized. When relay 278 is deenergized, contacts 270 and 304 return to the positions shown in FIG. 6 removing supply voltage from transistors 274 and 280 so that conduction of SCR 272 will cease. At this time the object 8 should be at the desired position. If it is not, by a distance greater than the spacing between fixed contact 286 and the ends of the movable bridging contacts 298 and 300 then one or the other bridging contacts will engage its contact 290 or 292 and the stationary contact 286. If a small amount of further counterclockwise movement is necessary to accurately position the object 8, then contacts 290 and 286 will be bridged by contact 298. With contact 270 engaging contact 288 because relay 278 is deenergized a circuit will be completed from the secondary 264 through the motor 260, contacts 270 and 278, contacts 286, 298 and 290 through diode 294 to the bus 268. By virtue of this circuit the motor 260 will "creep" in the counterclockwise direction in response to half-cycles of applied voltage conducted by the diode 294 until the contact 298 no longer bridges contacts 290 and 296. At this point, the motor 260 will stop with the object 8 positioned accurately to the desired position.

Were the positioning signal present at the terminal 184, the opposite operation would occur in that the transistor 280 would conduct as would the SCR 266 to cause the motor to rotate in the counterclockwise direction. Likewise, were fine positioning required in the direction opposite to that described above the contact 300 would bridge the contacts 286 and 292 causing "creeping" movement of the motor in the clockwise direction.

As described above, when a pushbutton switch 2 or a data source are used, the two digit decimal command is entered serially, that is, the tens digit first followed by the units digits. Also, it is desirable to prevent the entry of a new command until the previously entered command has been completed. Further, upon the completion of a command it is necessary to erase from memory that command, that is, condition the relay drive and decoding circuit 12 to receive new commands. In order to accomplish these functions, the transfer and clear circuit 13 is provided. FIG. 7 illustrates a circuit for performing these functions. The circuit of FIG. 7 includes the positive supply buses 100 and 154 and receives as one input at a terminal 310 the position or control signals at either of the terminals 184 or 200 and at another input the terminal 20', the initiate signal from the terminal 20 in the coding circuit 10 or from the data source 4.

In circuit 13, the terminal 20' is connected to the junction of a pair of capacitors 312 and 314 which have their opposite plates connected to the cathodes of a pair of SCRs 316 and 318, respectively. The anodes of each SCR are connected to the positive bus 100 while their cathodes are connected through diodes 322 and 324 to the ground bus 320. The gate electrodes of each SCR 316 and 318 are connected through resistors 326 and 328 to the bus 320. Terminals 88 and 90 correspond to the terminals 88 and 90 for supplying operating voltages to the firing circuits 84 and 86, respectively, in the relay drive circuit and are connected between the anodes of the SCRs 316 and 318, respectively, and the positive bus 100. An NPN-transistor 329 has its emitter connected to the bus 320 and its collector is connected to the anode of SCR 318. The base of the transistor 329 is connected through resistor 330 to bus 320 and a diode 332 and resistors 333 and 334 to

the anode of SCR 316. A capacitor 336 is connected from the junction of resistors 332 and 334 to ground.

The circuit thus far described is effective to transfer input signal information from the tens digits firing circuits 88 in FIG. 3 to the units digits firing circuits 90 so that the first input command digit will energize appropriate relays in the decoder 78 while the second input command digit energizes appropriate relays in the decoder 86. At the beginning of a cycle of operation using the push button switch 2, the operator will depress one of the switches 30 through 39. This causes an initiate signal to appear at the terminal 20 and digit command signals at one or more of terminals 22, 24, 26 and 28 as explained previously.

Prior to this time a PNP-transistor 340 connected in the bus 100 to function as a normally closed series switch is conducting so that voltage is present on that bus. The bus 154 which may be connected to the same power supply source as the bus 100 has provided therein a transistor 338 functioning as a normally open series switch and is therefore in the nonconducting state. It might be noted at this point that the transistor switch 338 performs the same role as the initiate switch 302 which shunts the relay contact 304 in the circuit shown in FIG. 6. These two switches would be used in alternative embodiments. Thus, in one embodiment where the numerical input would be from a hand switch 6 shown in FIG. 1, the normally open switch 302 may be provided on that switch to be manually closed by an operator after he has dialed the desired input command. When the system is used with a pushbutton switch 2 as shown in FIG. 1, then the initiate signal appearing on the terminal 20 and supplied to the terminal 20' will be effective to cause the transistor 338 to conduct momentarily, as will be described hereinafter.

With the transistor 340 conducting the terminal 88 is positive and the terminal 90 is at zero because initially SCRs 316 and 318 are in an off state. However, prior to the actuation of a pushbutton, the transistor 329 is conducting for its base is at a higher potential than its emitter and by virtue of this conduction the anode of the SCR 318 which is connected to the collector of the transistor 329 is at substantially zero voltage.

Consequently, when a positive going initiate pulse is supplied to the terminal 20' and at the same time one or more digit command signals appear at the terminals 22, 24, 26 and 28, only the firing circuits 84 will be able to respond and cause one or more of the SCRs in the group 58 to conduct for only that group of firing circuits has a positive potential supplied to its terminal 88. This is because the terminal 90 is effectively grounded due to the conduction of transistor 329. In this manner, the first input command is a tens digit unit. During the application of the initiate pulse the capacitors 312 and 314 will be charged with the right-hand plate of capacitor 312 positive while the left-hand plate of capacitor 314 will be positive. Upon the removal of the initiate pulse, the capacitors will discharge through the resistor 315 to ground. During the discharge of the capacitors, the cathodes of SCRs 316 and 318 will be negative with respect to their gate electrodes and either may conduct but only SCR 316 will conduct because the conduction of transistor 329 is holding down the anode of SCR 318.

During the portion of the operation just described, but prior to the conduction of SCR 316 the capacitor 336 had been charged with its upper plate positive. When SCR 316 is conducted, that capacitor discharged applying a delayed negative voltage to the base of transistor 329 turning it off late so that the anode potential of SCR 318 rose making it positive with respect to its cathode. Also the terminal 90 was no longer grounded so that the firing circuits 86 were now conditioned to respond to signals applied to their input terminals 22', 24', 26' and 28' and the conduction of SCR 316 grounded the terminal 88 preventing the firing circuits 84 from responding to input signals at their corresponding terminals. The next depression of a pushbutton by an operator again supplied an initiate pulse to the terminal 20' which charges the capacitors 312 and 314, as before, and at the same time the units input

command signal is supplied to the input terminals of the firing circuits 86 which may now cause conduction of appropriate ones of the SCRs in the group 60. As before, when the initiate pulse is removed, the capacitors 314 and 312 discharge through resistor 315 rendering the cathodes of the SCRs 316 and 318 negative with respect to their emitters. Inasmuch as the SCR 316 is already conducting as the result of the previous application of an initiate signal, only the SCR 318 will now conduct to again ground the terminal 90 so that any further depression of any of the push button switches will no longer be effective to put an input command into the system. This situation will remain as long as the SCRs 316 and 318 conduct and as will be described this period is determined by the time necessary to complete the movement of the object 8 to the position just commanded. Thus, while one command is being executed, a new one cannot be put into the system.

The remainder of the transfer and clear circuit is constituted by a pair of NPN-transistors 344 and 346 having their emitters connected to the ground bus 320 and their collectors connected through a load resistor 348 to the positive bus 100. The base of the transistor 344 is connected to the terminal 88 while the base of the transistor 346 is connected to the terminal 90. Also connected to the collectors of the transistors 344 and 346 is a capacitor 350. Included in the circuit with the capacitor 350 is the base of a transistor 352, the emitter of which is connected to the ground bus 320 and the collector of which is connected through a resistor 354 to the base of transistor 338. Another NPN-transistor 356 has its emitter connected to the ground bus 320 and its collector connected through a resistor 358 to the base of transistor 340. The base of the transistor 356 is connected through the resistor 360 to ground and through a capacitor 362 and a resistor 364 to the collector of transistor 338.

At the time of entry of a command, as pointed out, the terminal 88 is at a high potential and therefore the transistor 344 is conducting. By virtue of its conduction the junction 349 connecting that transistor to the capacitor 350 is at a low potential. Consequently, there is no charge on the capacitor 350. After the tens input command is inserted and the units input command is supplied, the potential at the terminal 88, as explained above, drops due to the conduction of the SCR 316. With the conduction of the SCR 316 the transistor 329 ceases conduction so that the potential at the terminal 90 rises. This sequence of operation causes the transistor 344 to cease conduction while the transistor 346 begins to conduct so that the potential at the junction 349 stays at a low value and there is still no charge on the capacitor 350. After the units command has been entered, both terminals 88 and 90 are low, the terminal 90 going low because of the conduction of the SCR 318. The capacitor 350 then charges through the base of the transistor 352 turning it on. When the transistor 352 conducts, it supplies base current to the transistor 338 causing it to conduct and supply voltage to the bus 154. As pointed out above, when voltage is supplied to that bus as a result either of the conduction of the transistor 338 or the closure of the switch 362, the relay 278 in FIG. 6 will be energized if a positioning signal is present on either the terminals 200 or 184 and the actual positioning portion of the cycle will commence. After the capacitor 350 has charged fully, the transistor 352 goes off turning off the transistor 338. The time constant of the charging circuit for the capacitor 350 is selected to be long enough to provide time for the relay 278 to be actuated and close its contact 304 and 270.

As explained previously at the beginning of the cycle, the transistor 340 was conducting permitting the input commands to be inserted into the system.

When the transistor 338 turns off or relay 278 drops out opening contact 304 removing the potential from bus 154, the capacitor 362 is discharged through the resistor 360 to ground applying a negative signal to the base of 356 momentarily turning it off. When the transistor 356 is turned off, its collector voltage increased and turned off the transistor 340 in the bus 100 removing the voltage from that bus. The removal of

the voltage momentarily from the bus 100 caused the SCRs 316 and 318 to cease conduction and also permitted the relays 92, 94, 96 and 98 in the decoding circuits to drop out and the SCRs in the SCR groups 58 and 60 to cease conduction. In this manner, the relay drive and decoding circuit was cleared to receive the next input signal.

Referring now to FIG. 8, there is shown in schematic fashion a wiring diagram of a control circuit in accordance with the invention, as applied to a slide projector. A source of alternating current of the conventional type is applied to the terminals 380 and 382. Terminal 380 is connected to the stationary contact 384 of a three-position switch having a movable bridging element 386 and stationary contacts 388 and 390. The stationary contact 390 is connected to the first terminal of a triac 408 and through a switch 400 to its gate electrode. The other terminal of the triac 408 is connected to the stationary contact 388 which is also connected to one side of the primary windings 392 and 402 of the transformers 394 and 404, respectively. The other side of each of the primary windings is returned to the AC supply terminal 382. A lamp 406 is connected to the stationary contact 390 and the first terminal of the triac 408 and to the terminal 382. The secondary winding 264 for the motor 260 is provided in the transformer 404 while a secondary winding 396 of the transformer 394 supplies alternating current for a fan motor 398 and for a DC power supply.

When it is desired to utilize a projector having as a part thereof a system in accordance with the invention, the bridging element 386 is actuated. When actuated to a position where it bridges contacts 388 and 384, circuits will be completed to the transformers 394 and 404 and to terminal 2 of the triac 408. At this point the switch 400 may be closed causing the triac 408 to conduct energizing the lamp 406. Upon further actuation of the bridging element 386 the contact 390 is connected to the contact 384 bypassing the triac so that the lamp is energized directly from the AC source connected to the terminals 380 and 382.

FIG. 9 illustrates generally a slide projector with which the system of the invention may be used. It is constituted by a housing or casing 420 rotatably supporting a circular slide tray generally designated 422. For purposes of illustration, it is to be assumed that the tray 422 includes 100 radially disposed slide-receiving spaces. The slide projector includes suitable means for lowering a slide from the tray to a projection gate or station and for lifting and returning such slide to its space in the tray. The control system according to the present invention may advance the tray to present at the slide-projection gate any slide space selected at random or in accordance with a program. It will be understood that the present invention is not to be limited with any particular type of slide projector.

The circular slide tray 422 includes inner and outer continuous walls 424 and 426 supporting therebetween 100 radially extending partition members 428 defining 100 slide-receiving spaces. Obviously, other trays may be used. For instance, at this time an 80-slide tray is available and with appropriate modifications may be used in conjunction with the invention. Projecting through the upper surface of the projector are switch-actuating elements 430 to provide access by the user to the various manually operated switches in the control circuit. Beneath the tray 422, as may be seen in FIG. 11, there is provided a central hub 432 to which is secured a fixed contact plate 434. The contact plate 434 includes a first annular series of separate contacts 436 constituting an inner ring of contacts each with a finger 438 extending to the periphery of the contact plate. An outer annular series of contacts 440 are provided as is a central or common contact 442. The central hub 432 is stationary and so accordingly is the contact plate 434. The shaft 262 of the positioning motor extends through the hub 432 and is rotatable therein. Fixedly secured to the shaft 262 so as to rotate with it is an upwardly facing series of clutch teeth 444. A cap 446, as shown in FIG. 10, is mounted on top of the shaft 262 and is provided on its inner surface with a series of downwardly facing clutch teeth 448 which mesh with

the teeth 444 when the cap is mounted on the shaft. The cap includes a radially extending tab 449 which is received within a notch in the tray 422; this provides a driving connection whereby rotation is imparted to the tray from the cap 446.

Secured to the underside of the cap so as to rotate therewith is a first single contact 450 and a second multiple contact 452. The contact 450 is dimensioned to connect any one of the inner annular set of contacts 436 to the common contact 442. Thus, contact 450 is provided with a finger 454 engaging various ones of the contacts in the ring 436 while a tab 456 diametrically opposed from the finger 454 engages the common contact 442. The contact 452 in the embodiment illustrated is provided with 10 equally spaced fingers any one of which may engage with only one of the extensions 438 of the contact segments 436. The relative spacing between the fingers of the contact 452 and the extensions 438 is such that only one finger may engage one of the extensions at a time while another finger will engage one of the outer ring of contact segments 440 to complete a circuit.

In order to operate the projector the switch 386 is actuated first bridging contacts 384 and 388 to complete a circuit to the fan motor 398, the transformer 404 and the DC supply. Further movement of the switch 386 also connects contact 390 with contact 384 supplying power to the lamp bypassing the triac 408. The input command is then inserted as described below, and once inserted the tray 422 will be rotated to its desired position when the switch 302 is closed.

Summarizing the operation of the position-control system, it may be seen an input command may be provided from the pushbutton switch 2, data-input source 4, or the hand switch 6. If the pushbutton switch 2 is utilized, "tens" and "units" input signals in binary coded decimal form appear at the terminals 20, 22, 24, 26 and 28. These signals are effective through the firing circuits 84 and 86 to operate selected SCRs of the groups 58 and 60. The selected SCRs upon conducting energize appropriate ones of the relays 92, 94, 96 or 98. The energization of these relays function to connect the switches 168 and 170 to desired ones of the contacts 122' through 131'. The switches are connected in the sequence determined by the operation of the transfer and clear circuit which provide for sequential energization of the buses 88 and 90. Upon the insertion of the command a position-control signal appears at either the terminal 184 or 200 and is effective to cause clockwise or counterclockwise rotation of the positioning motor 260 which drives the cap 446 and consequently the tray 422 toward the desired position. The movable contacts 450 and 452 provide a feedback signal which when it matches the input command signal causes the tray to stop at or near the desired position. At this point, if the tray is not precisely positioned, the fine positioning circuit 284 is effective to cause the tray to creep into the actual desired position.

While the invention has been described in connection with a specific embodiment thereof, it is to be understood that various changes and modifications may be made by those skilled in the art, and it is intended to cover by the claims appended hereto all such modifications and changes which fall within the scope of the invention.

We claim:

1. A remote-control system for positioning an object in accordance with an input command signal comprising means for providing an input command in the form of a multidigit, multiorder number representing a desired position; means for producing analog representations of each digit of the input number; means for producing analog representations of each digit of a number representing the actual position of the object; a first control circuit for comparing analog representations of higher order input numbers and actual position numbers and responsive to their relative values to produce a first position control signal effective to alternately cause clockwise and counterclockwise movement of the object to a position corresponding to the higher order input number, and a second control circuit for comparing analog representations of lower order input numbers and actual position numbers and respon-

sive to their relative values to produce a second position control signal effective to alternately cause clockwise and counterclockwise movement of the object to the desired position; and drive means responsive to the position control signals to move the object in a clockwise or counterclockwise direction.

2. A remote-control positioning system as set forth in claim 1 wherein said means for providing an input command is constituted by means for first providing electrical signals in a higher order decade of a decimal number and subsequently providing electrical signals representing a lower order decade of a decimal number.

3. A remote-control positioning system as set forth in claim 1 including circuit means receiving signals representing decade higher order input digits and further circuit means for receiving signals representing the lower order decade and transfer circuit means for enabling said receiving circuit means to sequentially receive the signals.

4. A remote-control positioning system as set forth in claim 3 wherein each of said receiving circuit means includes means for providing the analog representations of said input command number.

5. A remote-control positioning system as set forth in claim 4 wherein said means for providing an input command is constituted by a pushbutton switch having a plurality of normally open contacts, each contact representing a digit in a decimal number, and further including means for producing electrical signals representing the decimal number in a binary coded form.

6. A remote-control positioning system as set forth in claim 5 wherein each of said receiving circuit means comprises means for receiving the electrical signals in binary coded decimal form and producing the analog representations of each decimal number so received.

7. A remote-control positioning system as set forth in claim 1 wherein said means for producing analog representations of the command number provides a first analog representation of a higher order digit of the command number and a second analog representation of a lower order digit of the command number.

8. A remote-control positioning system as set forth in claim 7, in which the first control circuit comprises a first pair of circuits adapted to respectively produce position control signals effective to cause clockwise and counterclockwise movement of the object in accordance with the difference between the analog representations of the higher order command number and the actual position number of the object; and the second control circuit comprises a second pair of circuits adapted to respectively produce position control signals effective to cause clockwise and counterclockwise movement of the object in accordance with the difference between the analog representations of the lower order command number and the actual position number of the object.

9. A remote-control positioning system as set forth in claim 8 wherein said second pair of circuits each comprise a transistor and wherein the control element of one of said transistors is connected to said means for producing an analog representation of the number and the control element of the other transistor is connected to the means for producing an analog representation of the actual position of the object.

10. A remote-control positioning system as set forth in claim 9 including circuit means connected between said first and second circuits and said third and fourth circuits effective to shunt either said third and fourth circuits when said first and second circuits are producing position-control signals.

11. In a projector having an associated rotatable tray with a plurality of spaces for receiving transparencies to be projected, the improvement for advancing said tray to position any one of said spaces at a desired position comprising: means for providing electrical signals representing a numerical indication of said desired position as an input command for a desired tray position; means for converting the signals representing the input command in decimal numerical form to electrical analog values for each number in the command;

means for producing electrical analog values representing the actual tray position; a first circuit for comparing the electrical analog values representing the desired position with those representing the actual position to produce a position control signal effective to cause clockwise or counterclockwise movement of the tray; a second circuit for comparing the electrical analog values representing the desired position with those representing the actual position to produce a position control signal effective to cause clockwise or counterclockwise movement of the tray; means interconnecting said first and second circuits and said means for producing the analog representations whereby one of said first or second circuits will be operative dependent upon the relative values of the analog representations; and drive means responsive to the position-control signals to move the tray in a clockwise or counterclockwise direction.

12. The improvement of claim 11 wherein said means for providing the input command provides a first signal representing a higher order decade number and a second signal representing a lower order decade number, and said means producing electrical analog values of the actual position of the trays produces separate analog values for higher and lower order decade numbers representing the actual position.

13. The improvement of claim 12 wherein said first and second circuits compare the electrical analog values of the higher order decade numbers; and further including third and fourth circuits, each for comparing the electrical analog values of the lower order decade numbers and producing position control signals to cause either clockwise or counterclockwise rotation of the tray in response to the difference in the analog values.

14. The improvement of claim 12 wherein said first and second circuits each comprise a first transistor connected to said means providing the electrical analog values of the higher order decade command number and said means for producing the electrical analog value representing the higher order decade number of actual tray position whereby the conduction of said first transistor is controlled by the difference between the analog values, and a second transistor similarly connected and controlled, and means interconnecting said first and second transistors effective to prevent said first transistor from conducting when said second transistor is conducting.

15. The improvement of claim 14 wherein said first and second circuits compare the electrical analog values of the highest order decade numbers; and further including third and fourth circuits for comparing the electrical analog values of the lower order decade numbers and producing position control signals to cause either clockwise or counterclockwise rotation of the tray in response to the difference in analog values.

16. The improvement of claim 15 wherein said third and fourth circuits each comprise a transistor connected to said means providing an electrical analog value of the lower order decade command number and said means for producing the electrical analog value of the lower order decade number representing the actual position of the tray whereby the conduction of each transistor is controlled by the difference between the electrical analog values for the lower order decade numbers.

17. The improvement of claim 16 including means intercon-

necting said first and second circuits and said third and fourth circuits effective to prevent said third and fourth circuits from supplying a position control when either of said first or second circuits is conducting.

18. The improvement of claim 12 wherein said first signal represents said higher order decade number in a decimal form, said second signal represents said lower order decade number in a decimal form and including means for producing electrical signals for representing the input command number in a binary coded decimal form.

19. The improvement of claim 12 wherein said means for providing the input command number provides the number in a serial fashion and further including a transfer circuit connected between said means for providing the input command number and said means for converting the signals representing the input command number to electrical analog values for controlling said converting means to cause it to convert the first number provided to an electrical analog value representing a higher order decade decimal number and to convert the second number provided to an electrical analog representing a lower order decade decimal number.

20. The improvement of claim 19 wherein said transfer circuit is connected to the output of said first and second circuits and includes means responsive to the position control signal to prevent a new input command number from being converted to electrical analog values in the presence of a position control signal.

21. The improvement of claim 20 wherein said transfer circuit is responsive to the absence of a position-control signal to remove the electrical analog values representing an input command number from said converting means upon the completion of the movement of the tray to a desired position.

22. A remote control positioning system as set forth in claim 1, in which the means for providing an input command comprises a plurality of alternately operable input sources.

23. A remote control positioning system as set forth in claim 1, in which the control circuits are operable to produce position control signals effective to cause movement of the object through an arc of 180° or less to reach the desired position.

24. A remote control positioning system as set forth in claim 1 further comprising a fine positioning control circuit adapted to incrementally energize the drive means to move the object into the desired position should the object overshoot or undershoot such position.

25. A remote-control positioning system as set forth in claim 8 wherein said first pair of circuits each comprise two alternately conducting transistors and means connecting said transistors to said means for producing analog representations of the number and said means for producing an analog representation of the actual position of the object.

26. The improvement of claim 11, in which the means for providing electrical input signals comprises a plurality of alternately operable input sources.

27. The improvement of claim 13, in which said first, second, third and fourth circuits are operable to produce position control signals effective to cause rotation of the tray through an arc of 180° or less to reach the desired position.

28. The improvement of claim 13 further comprising a fine positioning control circuit adapted to incrementally energize the drive means to move the tray into the desired slide position should it overshoot or undershoot such position.

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